

April 1943

E-587

United States Department of Agriculture
Agricultural Research Administration
Bureau of Entomology and Plant Quarantine

A NEW OIL-EMULSION MOSQUITO LARVICIDE

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The enlarged program of mosquito control to include protection of the health and welfare of our armed forces makes it increasingly important that the most efficient methods of control should be used and that materials needed for the conduct of the war be conserved. An effective oil emulsion has recently been developed which contributes to this purpose by reducing the amount of oil required from 20-40 gallons per acre to about 6 gallons.

Tests made in 1941 showed that emulsions made with Diesel or stove oil and certain commercial emulsifiers were effective mosquito larvicides. In these laboratory tests the concentration of emulsifier was 3 percent of the oil, and 1 part of the mixture was then added to 7 or more parts of water.

In laboratory tests emulsions containing 1 to 1-1/2 gallons of oil per acre were found to give 100 percent mortality of several species of fourth instars of Aedes spp. and of the larvae of Culex pipiens L. in 24 hours, and 3-1/2 gallons per acre gave the same mortality of fourth instars of Theobaldia incidens Thoms. Theobaldia larvae have been shown to be more resistant to oil-containing larvicides than Aedes or Culex.^{1/} These emulsions were more toxic to pupae of Aedes vexans (Meig.) and A. lateralis (Meig.) than to their larvae, less than 1 gallon of oil per acre giving complete control.

The effectiveness of these emulsions against mosquito larvae and pupae is due to special qualities of the emulsifiers with which they are made. Of 26 emulsifiers that were tested, only 3 were found to be particularly effective--a sulfated sperm oil (Nopco 1216), a phthalic glyceryl alkyl

^{1/} Stage, H. H., and Yates, W. W. Comparative resistance of several species of mosquitoes to larvicides. N. J. Mosquito Extermin. Assoc. Proc. 28:(119)-126. 1941.

resin (B-1956), and an 18-carbon-chain complex amine (Amine 230X).^{2/} These 3 emulsifiers were about equally effective for this purpose, but they vary widely in price. It is possible that other emulsifiers may be found which are as good or better.

In 1941 a number of field tests of an emulsion containing Nopco 1216 were made against mosquitoes breeding in fresh water. In these tests an emulsion made with 1 part of Diesel oil containing 4 percent of the emulsifier added to 9 parts of water gave 98 percent mortality or better of Aedes, Culex, and Theobaldia larvae in 24 hours when applied at the rate of 50 gallons per acre.

In 1942 more extensive field tests with all three emulsifiers were made against the larvae of Aedes dorsalis (Mieg.) in irrigated regions, of A. vexans and A. lateralis in overflow swales along the Columbia River, of Culex tarsalis Coq. and Theobaldia inornata (Will.) in semipermanent ponds and roadside ditches, and of A. communis (De G.) and A. hexadontus Dyar in mountain meadows. Nearly all these tests were made against third and fourth instars, although pupae were present. Emulsions made up with 1 part of oil to 6 parts of water were used in most tests. In some, however, 1 part of oil to 9 parts of water was used, and in one test 97 percent mortality was obtained by atomizing the oil without emulsifying it. The results of these tests are shown in table 1.

In all the tests in which Diesel oil containing 4 percent of the emulsifier was applied at the rate of 5 gallons per acre, 90 to 100 percent mortality resulted in 24 hours. Pupae were destroyed more quickly than the larvae. A mortality of 90 percent or more resulted in all tests but one, on A. dorsalis, the application of 4 gallons per acre apparently being too light.

The value of this type of emulsion under practical field conditions was also proved when a mosquito-abatement district that had been using Diesel oil changed to the emulsion to conserve oil. In this work the strength of the emulsifier was 4 percent and 1 part of oil-emulsifier mixture was added to 6 parts of water. The emulsion was applied with knapsack sprayers at the rate of 40 gallons per acre. This was an application of approximately 5-2/3 gallons of oil per acre.

In this control work, which was directed against Aedes vexans and A. lateralis, the emulsion was as effective as the oil that had previously been used at the same rate. Previously the cost per acre for Diesel oil in the district had been \$2.40. The cost per acre for the emulsion was 80 cents,

^{2/} All 3 of these emulsifiers are materials which are sold under trade designations, and for which there is no adequate chemical description. The results reported are based on the particular samples received, and assurance cannot be given that there will not be considerable variation between lots. Nopco 1216 is made by the National Oil Products Co., Harrison, N. J.; B-1956 by Rohm and Haas Co., Philadelphia, Pa.; Amine 230X by Carbide and Carbon Chemicals Corp., New York, N. Y.

Table 1.--Field tests of Diesel oil emulsions, made with different emulsifiers, against mosquito larvae and pupae, Washington and Oregon, 1942

Emulsifier	Rate of application		Species of mosquito	Area tested	Water temperature	Mortality after 24 hours
	Oil	Emulsion				
	Gallons per acre			Acre	°F.	Percent
Nopco 1216	40	4	<u>Theobaldia</u> and <u>Culex</u> spp.	1/5		99
	40	4	<u>Aedes dorsalis</u>	1/4	65-67	76
	50	5	do.	1/16	65-67	100
	35	5	<u>Aedes vexans</u> and <u>A. lateralis</u>	1/3	70	99
	28	4	do.	1/6	70	98
	40	5-2/3	do.	7/10	70	100
	40	5-2/3	do.	7/10	70	100
	50	5	<u>Aedes communis</u> and <u>A. hexadontus</u>	1/5	70-74	2/ 100
	40	4	do.	1/5	70-74	98
	-	5	<u>Aedes dorsalis</u>	2/5	83-85	3/ 97
Amine 230X	40	4	<u>Theobaldia inornata</u> and <u>Culex tarsalis</u>	1/12	65-67	99
	45	5	<u>Aedes vexans</u> and <u>A. lateralis</u>	1/7	70	93
	1/ 35	5	do.	1/4	68-74	98
	40	4	<u>Aedes communis</u> and <u>A. hexadontus</u>	1/5	70-74	90
B-1956	35	5	<u>Aedes vexans</u> and <u>A. lateralis</u>	1/7	68-74	100

- 1/ Strength of emulsifier 3 percent; in all other tests 4 percent.
2/ 5 hours after treatment all the pupae and 89 percent of the larvae were dead.
3/ Estimated kill based on kill of 93 percent in 18 hours.

36 cents for the oil and 44 cents for the emulsifier. The comparatively small amount of oil required when the emulsion was used was also found to be an advantage in some areas where the roads were impassable and the oil had to be transported by boats or by manpower.

Both the field tests and the control work by the abatement district were directed against mosquitoes breeding in fresh water. In preliminary tests on salt-marsh mosquito larvae, emulsions made with Nopco 1216 were less effective.^{3/} No tests have yet been made on salt water with emulsions containing Amine 230X or B-1956.

METHODS OF MIXING AND STRENGTH OF APPLICATION

The most effective ratio of oil to water for this type of emulsion will vary with the area to be covered and the equipment used for applying it. For the average fresh-water breeding area as found in Oregon and Washington, 1 part of oil containing 4 percent of emulsifier to 5 parts of water applied at the rate of 30 gallons per acre or 1 part of oil containing 4 percent of emulsifier to 6 parts of water applied at the rate of 40 gallons per acre insures adequate coverage and complete control.^{4/} A larger proportion of water should be used on waters containing much vegetation or debris.

The following formula is effective on fresh water: 1 pint of emulsifier, 3 gallons of oil, and 15 or 18 gallons of water. The emulsifier should first be added to the oil and thoroughly stirred. The water should then be added and mixed well with a wooden paddle to make an emulsion.

^{3/} These tests were made by H. H. Stage and W. C. McDuffie at New Smyrna Beach, Fla.

^{4/} Not less than 7 parts of water should be added when Amine 230X is used; otherwise the emulsion will be too thick for spraying.